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Review Report

Journey to the Unknown: Human/ Social Science in Antarctica for Outer Space

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Journey to the Unknown:
To what extent do human/ social science research in Antarctica apply to human exploration in outer space?

Abstract

This paper reviews literature related to the use of human/ social science research in Antarctica for human exploration in outer space. It compares and contrasts human experience in both contexts, and highlights the uses and development of human/ social science research in Antarctica for human experience in space, especially for long-duration missions.

Background and Discussion

Development of human/ social science research in space

Driven by scientific, technological, political, cultural, and economical reasons, human exploration to outer space, such as Lunar and Mars, has attracted major attention in USA, Soviet (now Russia), Europe, and China space programmes since 1970s (Musson, 1999). Besides the interest in astrobiology, geology, mineralogy, and atmospheric research to understand planetary formation and evolution process, human/ social science in space research develops alongside with the increasing interest in long-duration space missions and diversity of space and ground crews, in terms of sex, age, experience, occupation, and nationality (Horneck, 2002). For examples, in the case of USA, after the introduction of Skylab for longer duration space missions in 1973, and from the experience in joint Shuttle-Mir programme with Soviet where US astronauts who were hosted on Mir space station that functioned under Russian command and mission control, reported difficulty in social-psychological adaptation on Mir (Burrough, 1998; Musson, 1999). Cultural issues, language, and stress in isolation and confined environment were addressed (Burrough, 1998; Musson, 1999).

With human civilization expanding into solar system and since the establishment of International Space Station (ISS) in 2000, human/ social science in space is expected to be one of the key factors for successful human exploration to long-duration space missions (Horneck, 2002; Manzey, 2004; Robinson, et al., 2007). Over the years, human/ social science in space research focuses on: 1) the testing of research and technology development and system for life support; 2) the human factors for space traveling such as biomedical, psychiatry, psychological, and environmental aspects before, during, and after space mission; and 3) the operational issues for spaceflight and planetary habitat (Anderson et al., 1990; Horneck, 2002; Robinson et al., 2007). Due to different space missions from those in ISS, extended surface operations and unique transit times in the case of Mars and diverse space crews will be the challenges of future human/ social research (Harrison, 2004). For example, HUMEX study (ESA SP-1264) conducted by Europe Space Agency (ESA) has identified four critical areas for future research and development: 1) radiation health risks; 2) health transfer phases and severely augmented in case of an eruption of a solar partial event; 3) psychological risks; and 4) the requirement of bioregenerative life support systems (Horneck et al., 2006).

Antarctica: A natural laboratory and space analogue

In general, the research interests on human risks and experience in space can be divided into: 1) laboratory and simulation; 2) natural, physical environment; and 3) constructed environment.

Although simulation in laboratory are important to prepare space crews for their missions, it is recognized that natural laboratory or space analogue on earth, such as those in polar regions, submarines, and underwater habitats are critical for real-life and real-time observation of human behaviors and experience similar to those in space (Clancey, 2002; Manzey, 2004). As an example, the cold, dry, and radiation condition, as well as difficulty in getting support in remote areas in Dry Valley, Antarctica, is suggested to be similar to that in Mars and therefore an ideal testing ground for space crew simulation (Harrison, 1995). Each analogue environment, including Antarctica, offers advantages to study human behavioral health in natural setting as compare with those in laboratory, from ethical, legal, medical, and scientific perspectives (Harrison, 2004). In addition to the concerns for physical environment, constructed environment such as the design, support, and facilities of spaceships, submarines, research stations, field tents, and campsites have gradually attracted some attentions in recent years (Yan & England, 2001; Horneck, 2002).

Nature of research and methods of inquiry in space and in Antarctica

The research nature for space and Antarctica are very similar in most aspects: 1) the research population and methods of inquiry; and 2) habitat. Similar to space research, most of the polar research samples are relatively small as compare with social science studies elsewhere. The samples for study are traditionally homogeneous, in terms of gender (i.e., more male), race (i.e., Anglo-Saxon), and limited range of occupations (i.e., scientists and support personnel). The increasing use of civilian instead of military as support personnel in some national Antarctic programmes, as well as recent trends of international collaboration of scientific research and support personnel are similar to those in some space programmes (Burrough, 1998; Musson, 1999; Ritsher, 2005). From the aspect of habitat, personnel in both contexts has limited privacy (due to the isolated and confined environment); utter silence; absent of 24 hour day' (total darkness or daylight); and extreme environment, to name a few (Suedfeld & Steel, 2000; Sandal, 2001).

Human exploration in Antarctica and Space: Research interests, theories, and trends

As one of the space analogue on Earth, Antarctica provides a testing ground for the understanding of human physiological and psychological challenges in extreme environment. Nevertheless, one should not confuse simulators and analogue environment with space environment due to some differences between them, such as the effect of microgravity on behavioral health issues (Harrison, 2004).

The main research interests on human/ social science in these isolated and confined environments (ICE) (Palinkas, 2003) and capsule environment (Suedfeld & Steel, 2000) include the following aspects:

- Health, safety, and environmental aspects
- Selection and human performance
- Social-psychological aspects
- Support needs: Human, logistic, life, and real-time support; crew member and crew-ground interactions; abort and fast return capability (Training: pre-, during, and post-Ice)
- Design, facilities, and support technology

In general, these challenges are divided into three stages of human experience in completing space or Antarctic missions: 1) pre-mission; 2) during mission (traveling and on-site); and 3) end of mission. One of the common experiences that space and Antarctic crews share is the similar process and stressors face throughout their mission in these unusual environments (Manzey, 2004). These processes and stressors are highlighted below in brief with the aim to address the research findings in Antarctica that might have implications on space programmes. However, it is beyond the scope of this report to discuss each factor in depth.

Pre-mission

Selection for deployment: Psychological, medical, and intellectual "fitness"

Due to the high risks, challenges, and cost of operating in space and Antarctica, selection of personnel for deployment are critical aspect for the success of accomplishing the missions, especially for long-duration missions such as winter-over in Antarctica and long-duration spaceflight (Musson et al., 2004; Iain et al., 2007). Unlike space programmes, there is usually no explicit intellectual assessment in Antarctic national programmes. Psychiatric criteria are usually used for "selecting out" individuals with psychiatric disorders, while psychological criteria are usually used for "selecting in", in an attempt to predict human adaptation and performance in these environment (Santy, 1994; Kanas & Manzey, 2003). Though not as rigor as the selection in space programmes, the use of psychological assessment for selection are unresolved issues in different space and Antarctica national programmes (Olson, 2002; Musson et al., 2004; Iain et al., 2007). For examples, Antarctica national programmes from USA, Canada, Chile, French, New Zealand, and Australia use psychological battery for selection, while the selection panel from UK chooses to do without it (Olson, 2002; Iain et al., 2007). Some psychological inventories such as NEO-FFI (the "Big Five" personality inventory) and PCI (Personal Characteristics Inventory) are used in some of the Antarctic national programmes and space programmes (Steel et al., 1997; Musson et al, 2004). Similar to the Antarctic national programmes, the absence of standard criteria for assessing astronaut and cosmonaut performance across space programmes and limited research opportunities have made it difficult to evaluate the predictive utility of personality measures in space (Musson et al., 2004; Iain et al., 2007). Nevertheless, it is suggested that to include psychological inventory in the selection methods increases the chance of identifying good performance and reduces the chance of selecting poor performers (Musson et al., 2004; Iain et al., 2007).

Human, Environment, Technologies, Training, and Preparation

Two types of environments, the natural environment and constructed environment, are relevant to the study of space and polar missions. Besides environmental psychology, human factors engineering (or ergonomics) is best known for designing and engineering tools and environments to fit the needs of the human users (Sundstrom et al., 1996; Harrison, 2005). It includes selection, training, structuring of situations and the process of organising, allocating, and pacing task (Harrison, 2005). This involves the interdisciplinary understanding of human physical abilities (e.g., anatomy, physiology, biomechanics) and cognitive abilities (e.g., vision, audition, memory, retrieval, problem solving), for examples biology, engineering, and cognitive science (Manzey, 2004; Harrison, 2005). This is especially crucial for space crews who need to be multitasking in ICE for long-duration missions. For examples, poor habitat or equipment design (e.g., autonomous systems), marginal life support systems (e.g., telemedicine), inadequate space, inappropriate spacesuits, faulty communication will increase the health and safety risks of the space crews, especially in the face of communication difficulty and time delay between Earth and Mars (Dudley-Rowley et al., 2001; Horneck, 2002; Harrison, 2004, 2005). This implies the psychological aspect of human-machine interface design is in need for future research.

Although it is important to understand the effectiveness of various training programmes conduct in space programmes and Antarctic national programmes as they might affect the adaptation of the space and polar crews during their missions, there is insufficient research done in this area (Manzey, 2004). For examples, the effectiveness of training needs analysis, selection of training methods and techniques, as well as the choice of training evaluation techniques to increase the double-loop learning capability of the crews to increase their likelihood to adapt to unpredicted circumstances, especially for long-duration missions (Horneck et al, 2006). This might be due to the lack of involvement of social scientists in this process. However, it is common that lectures, simulations, and field trainings are common methods used to deliver training content in both contexts.

During the pre-departure stage, both space and polar crews and their families undergoing a series of adjustment, psychologically, physiologically, and financially. Although professional assistance have been given to the crews in space programmes and some Antarctic national programmes, insufficient research has been done to explore their implications on the mission and crews during long-duration missions.

During the Mission

In general, there are at least two areas of research been developed in Antarctica that contribute to the human/ social science research in space programmes: 1) bio-medical; 2) social-psychological factors and human performance. These research areas are well-developed by the North American and European researchers, potentially due to the wider spread of research stations in Antarctica, the use of psychological assessment, scientific interests and strategies of their national programmes (space and Antarctica) in human/ social science research in these extreme environment. Some of the research works were done on non-Western Antarctic national programmes, including Japan and India. The increasing collaboration among polar scientists from diverse backgrounds such as professional expertise) and nationality, as well as the sharing of polar research stations will be a good analogue for space programmes with similar trends in near future.

Bio-medical Issues

Various bio-medical issues have been the focus of research in Antarctica and space in recent years, including:

- Cognitive and human performance found in Antarctica and space: Sleep and circadian rhythms (Olson, 2002; Kanas & Manzey, 2003; Harrison, 2005)
- Ultraviolet light exposure in Antarctica: Since the discovery of ozone layer at the Halley research station in the early 1980s, there are increasing research interest in the effects of UVB on human health, especially on skin cancer, resistance to infectious disease and cataract formation, potential risk on cornea including photokeratitis (effect on cornea resulting from UV blight exposure), to name a few (Olson, 2002; Horneck, 2002).
- Endocrinology in Antarctica: Effects of lack of solar UVB radiation on hormonal function during winter, including reduced hydroxylation of vitamin D, dysfunction of tri-iodothyronine (T3) (or polar T3 syndrome. It has potential link with the changes in mood and cognition).
- Immunology in Antarctica: Reduced immune function among the winter-over (Olson, 2002).
- Cold physiology (or cold adaptation) in Antarctica : Algorithms for cold adaptation, adaptation of shivering thermogenesis, the role of cytokines in thermoregulatory responses, frostbite (Nelson, 1968; Olson, 2002)
- Microgravity-included disorders found in space: Motion, bone loss, cardiovascular orthostatic intolerance, muscle atrophy, and sensorimotor system (Horneck, et al., 2006).

Social-psychological Issues

From social-psychological aspects, there are similarities and differences in research findings in, and between Antarctica and space context, potentially due to small sample size and research methodologies used.

Individual Domain Issues

- Physiological and psychological adaptation and stages (Gunderson & Palinkas, 1998; Suedfeld, 1998; Taylor, 1998; Palinkas & Houseal, 2000; Steel, 2001; Kanas & Manzey, 2003; Manzey, 2004; Harrison, 2005). In general, four stages of adaptation patterns are observed in winter-over crews in Antarctica and long-duration space missions. During the first stage, crews attempt to adapt to the physical environment, routine of work and live, and workload. Second stage starts after the crews adapt fully to the new living condition but yet to suffer physiological and psychologically the impacts of ICE. Third stage (or third-quarter phenomena) usually involves severe stressors cause by (social) monotony and boredom related to hypoactivity and hypostimulation, isolated of family and friends, and restricted social contacts within small group. Symptoms including emotional stability, hypersensitivity, depressive reactions, decline of motivation and vigor are observed. However, the concepts of ‘salutogenic’ (or health-enhancing aspect from positive psychology perspective) suggested that it can be overcome or reduced with appropriate countermeasures. The final stage occurred shortly before the end of the mission where feelings of euphoria and uncertainty have been observed prior to their return to the ‘civilised world’.
- Polar self image (Rosnet, et al., 2000)
- Psychological support and countermeasures in both contexts (Manzey, 2004; Harrison, 2005; Schmidt, et al., 2005).
- Psychiatric disorders in Antarctica (Palinkas et al., 2001, 2004)
- The Earth-out-of view phenomenon is suggested to be one of the major challenges for long-duration space flights (Kanas & Manzey, 2003; Manzey, 2004)

Organisational and Interpersonal Domain Issues

- Mission objectives in Antarctica and space (Dudley-Rowley, 1999)
- Crew size and time (e.g., duration of missions; mission interval; cycle; winter vs. summer) (Dudley-Rowley, 1999; Dudley-Rowley et al., 2001)
- Sex/ gender issues in space and Antarctica (Leon & Sandal, 2003; Woodmanse, 2006)

- Composition of crew: homogeneous vs. heterogeneous (e.g., cultural issues such as crews from collectivism society vs. individualistic society) , group development, dynamic, autonomy, roles, inter- vs. intra-group, social and communication network, leadership, decision-making, problem-solving, ground-crew interaction, support, performance (Dudley-Rowley, 1999; Sandal, 2001; Tafforin, 2004; Schmidt et al., 2005; Nolan, 2005; Ritsher, 2005)

Return and After-mission

- Physiological and psychological adaptation during and after the mission in Antarctica and space: Mixed feelings (yet the need to stay alert and motivated during the return journey of space missions) (Manzey, 2004). Insufficient scientific research has been done on this area in Antarctica.

In sum, although advancement of technology (e.g., telecommunication and logistic support) has improved the life of those who work and live in Antarctica since 1960s, three types of abilities have identified and remain valid for successful adaptation to polar missions: Task abilities, emotional stability, and social ability (Gunderson, 1973; Taylor, 1987, 2002; Steel et al., 1997; Palinkas, 2003). Interestingly, research findings from space programmes are not too far away from this finding (Kanas & Manzey, 2003)

Conclusion and Recommendations

Holistic view of human science in extreme environment

It is suggested to take holistic approach to understand the factors that might have simultaneously contributed to human adaptation in these unique and extreme environments. A successful overall research programme in space and Antarctica should take into considerations the following factors (Taylor, 2002; Harrison, 2004; Nolan, 2005; Ritsher, 2005; Steel, 2005):

1. multiplicity of research methods, as appropriate (e.g., archival research, case histories, surveys, naturalistic field studies, and experiments);
2. multiplicity of settings, as appropriate (e.g., space simulators, spaceflight-analogous environment, and space itself);
3. contributing factors to individual and group adaptation and performance such as:
    - individual factors (e.g., physical and mental fatigue, mental health problems, motivation decline, social withdrawal, inability to cope with overload or to respond flexibly under stress, human-environment interface, human-machine interface);
    - group factors (e.g., interpersonal dynamic, communication, leadership, coordination, inter- and intra-group conflicts, crews and families);
    - organisational factors (e.g., lack of sufficient regard for behavioral issues, and failure to accept implications of behavioral health research);
    - cultural factors (e.g., astronaut/ cosmonaut culture, engineering culture, and ground crews); and
    - time factors (e.g., learning experience and adaptation throughout the missions).

    According to Organizational Similarity Theory, stressors do not solely rely on its environments (physical and social) characteristics (Manzey, 2004). Instead, its psychological meaning to the individual in the particular context at a given time should be the focus of the study (Manzey, 2004; Steel, 2005). In addition to that, Functional Similarity Theory suggests that one should take into account the possibilities and constraints in performing the trained tasks during the missions prior to carrying out the missions. For example, skill learning and retention are critical and may become a problem during long-duration space missions (Manzey, 2004).
4. Behavioural health as an interdisciplinary field (e.g., psychiatry, anthropology, education, sociology, and several fields of psychology including personality, social, industrial, organisational, environmental, and clinical).

These imply that one should be caution in generalizing the research findings due to:

1. the nature of small group sample and the methods of inquiry used;
2. the ongoing research and discoveries;

3. most research areas are interrelated (e.g., the potential impacts of bio-medical condition of a crew on his/her social-psychological adaptation in unfamiliar environment in different stages of the missions); and
4. some of the features in Antarctica are not similar to those in space (e.g., microgravity).

Future of human/ social science in Antarctica for outer space

The development of human/ social science in Antarctica came a long way for the past 30 years (Taylor 1987; Lugg & Shepanek, 1999; Suedfeld & Weiss, 2000; Suedfeld & Weiszbeck, 2004). The lack of human/ social science research in Antarctica, excepts for psychological selection of Antarctic personnel adapted mainly from the military practices, was reported in 1968 (Nelson, 1968). However, it has attracted much attention since the publication of *Antarctic Psychology* (1987) by A.W Taylor from New Zealand. Of the publications in English on human/ social science in Antarctica for space, majority of them are from government funded projects from North America (e.g., Lawrence Palinkas from USA and Peter Suedfeld from Canada) and Europe.

Interestingly, similar observation has addressed the small number of human/ social science research in Antarctica in International Polar Year 2007-2008 (Hovelsrud & Krupnik, 2006). Perhaps due to the challenges in securing research funding in the case of Antarctic research and transfer of knowledge between the two contexts (i.e., space and Antarctica), human/ social science research in space programmes seems to develop more rapidly as compares with those in Antarctica in recent years (Manzey, 2004). Various reasons might have contributed to this phenomenon: 1) the national science strategies for space and Antarctica research; 2) the difficulty of conducting human/ social science research in space and Antarctica in terms of accessibility and funding; 3) insufficient collaboration of human/ social science research between Antarctica and space programmes (excepts in North America); as well as 4) insufficient apprenticeship programmes to nurture new generation of human/ social scientists to participate in both contexts.

In conclusion, it is suggested that human/ social science research in Antarctica will remain as a window to understand human behavioural health in outer space, especially for long-duration missions. However, the journey to the unknown will depend very much on various factors, including knowledge sharing and collaboration of the stakeholders from space and polar programmes. For examples, international collaboration among Artic, Antarctica, and space programmes, such as the scientific communities, policy makers, programme managers, scientists including the social scientists, engineers, and support personnel.

References

Andersen, D.T., Whatton, R.A. Jr., & Rummel, J.D. (1990). An Antarctic research outpost as a model for planetary exploration. *Journal of The British Interplanetary Society, 43,* 499-504.

Burrough, B. (1998). *Dragonfly: NASA and the Crisis Aboard Mir.* USA: HarperCollins.

Clancey, W.J. (2002). A framework for analog studies of Mars surface operations: Using the Flashline Mars Arctic Research Station. *USA, Nasa/Ames Research Center,* 1-18.

Dudley-Rowley, M. (1999). Dysfunctional behavior and performance of team personnel in space and analog polar environments: Implications for Mars mission. 1-14.

Dudley-Rowley, M., Whitney, S., Bishop, S. Caldwell, B., & Nolan, P.D. (2001). Crew size, composition, and time: implications for habitat and workplace design in extreme environments. 1-13.

Gunderson, E.K.E. (1973). Individual behaviour in confined or isolated groups. In J.E. Rasmussen (ed.), *Man in Isolation and Confinement,* 145-164. Chicago: Aldine.

Gunderson, E.K. E. & Palinkas, L.A. (1998). Psychological studies in the US Antarctic Program: A review. In A.J.W. Taylor (Eds), *Proceedings of the human factors in polar psychology with some implications for space, Sydney, August 30, 1998* (pp. 5-8). UK: Scott Polar Research Institute.

Harrison, A.A. (1995). Antarctica: Prototype for outer space (NASA-TM-108095). *Scott Polar Research Institute, University of Cambridge,* 1-13.

Harrison, A.A. (March, 2004). *New directions in behavioral health: A workshop integrating research and application.* Conference Report, NASA Nag 9-1572, 10 March, 2004 (pp. 1-48). USA: NASA.

Harrison, A.A. (June, 2005). Behavioral health: Integrating research and application in support of exploration missions. *Aviation, Space, and Environmental Medicine, 76(6), Sec. II,* B3-B12.

Horneck, G. (2002). *Human missions to Mars and Astrobiology: Two sides of the same coin. Proceedings of the Second European Workshop on Exo/ Astrobiology, Graz, Austra, 16-19 September, 2002. (ESA SP-518, November 2002)* (pp. 269-273). European Space Agengy, Nasa Astrophysical Data System.

Horneck, G., Facius, R., Reichert, M., Rettberg, P., Seboldt, W., Manzey, D., Comet, B., Maillet, A., Preiss, H., Schauer, L., Dussap, C.G., Poughon, L., Belyavin, A., Reitz, G., Baumstark-Khan, & Gerzer, R. (2006). HUMEX, a study on the survivability and adaptation of humans to long-duration exploratory missions, part II: Missions to Mars. *Advances in Space Research.* 38(4), 752-759.

Hovelsrud, G.K. & Krupnik, I. (September, 2006). IPY 2007-08 and Social/ Human Sciences: An Update. *Artic, InfoNorth, 59(3),* 341-348.

Iain, G., Eriksen, H.R.; Marquis, P; Orre, I.J., Palinkas, L.A., Suedfeld, P., Svensen, E., & Ursin, H. (August, 2007). Psychological selection of Antarctic personnel: The “SOAP” instrument. *Aviation, Space, and Environmental Medicine, 78(8),* 793-800.

Kanas, N. & Manzey, D. (2003). *Space Psychology and Psychiatry.* USA: Microcosm Press.

Leon, G.R. & Sandal, G.M. (2003). Women and couples in isolated extreme environments: Applications for long-duration missions. *Acta Astronautica, 53,* 259-267.

Lugg, D., & Shepanek, M. (1999). Space analogue studies in Antarctica. *Acta Astronautica, 44, Nos.1-12,* 693-699.

Manzey, D. (August-November, 2004). Human missions to Mars: New psychological challenges and research issues. *Acta Astronautice, 33(3-9),* 781-790.

Musson, D.M. (1999). Psychological concerns in long duration spaceflight: Comparisons of piloted Mars mission designs. USA, Technical Report 99-06.

Musson, D.M., Sandal, G.M., & Helmerich R.L. (April, 2004). Personality characteristics and trait clusters in final stage astronaut selection. *Aviation, Space, and Environmental Medicine,75(4), Sec. I,* 342-349.

Nelson, B. (January, 1968). Science in Antarctica: Problems and opportunities “On the Ice”. *Science 26, 159(3813),* 407-412.

Nolan, P.D. (November, 2005). Effects of organisational structure on the behavior and performance of polar and space work teams. USA: University of South Carolina.

Olson, J.J. (October, 2002). Antarctica: A review of recent medical research. *Trends in Pharmacological Sciences, 23(10),* 487-490.

Palinkas, L.A. (June, 2001). Psychological issues in long-term space flight: Overview. *Gravitational and Space Biology Bulletin, 14(2),* 25-33.

Palinkas, L.A. (May, 2003). The psychology of isolated and confined environments: Understanding human behaviour in Antarctica. *American Psychologist, 58(5),* 353-363.

Palinkas, L.A., Glogower, F., Dembert, M., Hansen, K., & Smullen, R. (2001). Psychiatric morbidity after extended isolation and confinement in an extreme environment: The Antarctic-space analog program. 1-2.

Palinkas, L.A., Glogower, F., Dembert, M., Hansen, K., & Smullen, R. (2004). Incidence of psychiatric disorders after extended residence in Antarctica. *International Journal of Circumpolar Health, 63(2),* 157-168.

Palinkas, L.A. & Houseal. M. (January, 2000). Stages of change in mood and behavior during a winter in Antarctica. *Environment and Behaviour, 32(1),* 128-141.

Ritsher, J.B. (2005). Cultural factors and the international space station. *Aviation, Space, and Environmental Medicine, 76(6),* 135-144.

Robinson, J.A., Thumm,, T.L., & Thomas, D.A. (June-August, 2007). NASA utilization of the International Space Station and the vision for space exploration. *Acta Astronautica, 61(1-6),* 176-184.

Rosnet, E., Scanff, C. and Sagal, Marc-Simon. (January, 2000). How self-image and personality influence performance in an isolated environment. *Environment and Behaviour, 32*(1), 18-31.

Sandal, G.M. (June, 2001). Psychological issues in space: Future challenges. *Gravitational and Space Biology Bulletin, 14(2),*47-54.

Santy, PA. (1994). *Choosing the Right Stuff: The Psychological Selection of Astronauts and Cosmonauts*. London: Praeger

Schmidt, L.L., Wood, J., & Lugg, D.J. (May-June, 2005). Gender differences in leader and follower perceptions of social support in Antarctica. *Acta Astronautica, 56(9-12),* 923-931.

Steel, G.D. (January, 2001). Polar moods: The third-quarter phenomena in the Antarctic. *Environment and Behaviour, 33*(1), 126-133.

Steel, G.D. (2005). Whole lot of parts: Stress in extreme environments. *Aviation, Space, and Environmental Medicine,76(6,Suppl),* B67-73.

Steel,G.D., Suedfeld, P., Peri, A., & Palinkas, L. (1997). People in high latitudes: The "Big Five" personality characteristics of the circumpolar sojourner. *Environment and Behaviour, 29,* 324-347.

Suedfeld, P. (1987). Extreme and unusual environments. In *Handbook of Environmental Psychology*, ed. D Stokols, I Altman, Vol. 1, 863-86. New York: Wiley

Suedfeld, P. (1998). What can abnormal environments tell us about normal people? Polar station as natural psychology laboratories. *Journal of Environmental Psychology, 18,* 95-102.

Suedfeld, P., & Steel, G.D. (2000). The environmental psychology of capsule environments. *Annual Review of Psychology*, *51*, 237-253.

Suedfeld, P., & Weiss, K. (January, 2000). Antarctica: Natural laboratory and space analogue for psychological research. *Environment and Behavior, 32(7),* 7-17.

Suedfeld, P., & Weiszbeck, T. (July, 2004). The impacts of outer space and inner space. *Aviation, Space, and Environmental Medicine,75(7), Sec .II,* C6-C9.

Sundstrom, E., Bell, P.A., Busby, P.L., & Asmus, C. (1996). Environmental Psychology 1989-1994. *Annual Review of Psychology, 47, Academic Research Library,* 485-512.

Tafforin, C. (July, 2004). Ethological analysis of a polar team in the French Antarctic station Dumont d'Urville as simulation of space teams for future interplanetary missions. *Acta Astronautica, 55(1),* 51-60.

Taylor, A.J.W. (1987). *Antarctic Psychology.* New Zealand: Science Information Publishing Centre.

Taylor, A.J.W. (1998). Human factors in polar psychology with some implications for space. 24th International Congress of Psychology, Sydney, Australia, August 30, 1998. UK: Scott Polar Research Institute.

Taylor, A.J.W. (2002). Interdisciplinary development in hazardous environment research: A silent tribute to general systems theory? *New Zealand: International Journal of Circumpolar Health*, 216-223.

Woodmanse, L.S. (2006). *Sex in Space.* Canada: CG Publishing Inc.

Yan, X.Y.W, & England, M.E. (May, 2001). Design evaluation of an Arctic research station: From a user perspective. *Environment and behavior, 33(3),* 449-470.